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LIME AND OTHER SOIL AMENDMENTS

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USE OF AMENDMENTS

Many soils in humid areas are too acid for maximum production of many field crops. Liming is widely practised to reduce soil acidity, particularly in parts of Eastern Canada. In the prairie areas, soils are usually neutral or slightly alkaline and liming is seldom necessary.

Ground limestone is the material usually applied to soils to counteract acidity. Lime also adds calcium, an important plant nutrient, and magnesium if a dolomitic lime is used. Deposits of marl, and the shells of crabs, lobsters and other shellfish, are useful sources of lime.

Liming affects the solubility of many compounds in the soil and their availability to crops. By neutralizing acidity, it also gives a better environment for the soil bacteria to do their work. Avoid excessive liming, however, because this can sometimes result in adverse growing conditions.

A few plants, such as some ornamentals, need quite an acid soil for best growth. If a soil is neutral to slightly acid and does not contain any free lime, applications of sulphur will make it more acid. The sulphur is changed to sulphuric acid by certain soil bacteria.

Sulphur is also a plant nutrient, and there are some areas in Canada, particularly in the Gray Wooded soil zone, where sulphur must be used for satisfactory crop growth. Gypsum is a good material to apply to soil as a source of sulphur.

LIME AND OTHER SOIL AMENDMENTS

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Many soils in humid regions are acid. Applications of lime to such soils are necessary for good crop growth. This publication tells what compounds may be used for liming and what effects liming has on the soil and the crop, and gives other information that may help the farmer or gardener who wishes to use lime on his soil. Comments are also given on use of sulphur in increasing acidity.

LIME

Liming compounds are primarily soil amendments. They consist mainly of limestone, both calcitic and dolomitic, hydrated lime, burnt lime, marl, and oyster or other shells. These materials improve the soil chemically by lessening soil acidity as well as by adding plant nutrients, and biologically by stimulating bacterial action. The best remedy for soils that are too acid for good crop growth is to apply liming compounds. This practice has been in use throughout the world for centuries. Ground limestone and marl are the cheapest, most satisfactory and most commonly used sources of lime for the correction of soil acidity.

Soil Reaction and Crop Growth

Lime (calcium and magnesium) compounds in the soil may be dissolved and lost through drainage. The steady loss of calcium is responsible for the development and increase of acidity. Soil reaction or the degree of acidity or alkalinity is often expressed by figures ranging from 0 to 14, which are known as pH values. For most soils, these figures lie between 4.5 and 9. The degrees of acidity are indicated approximately by the following pH values:

Very strongly acid	pH 3.5 to 4.4
Strongly acid	pH 4.5 to 5.4
Moderately acid	pH 5.5 to 6.1
Slightly acid	pH 6.2 to 6.7
Neutral	pH 6.8 to 7.2[1]
Mildly alkaline	pH 7.3 to 8.0
Moderately alkaline	pH 8.1 to 9.0
Strongly alkaline	pH 9.1 and over

Crops grow satisfactorily under a fairly wide range of reactions if there is enough available plant food and humus in the soil and drainage is satisfactory. Most of the common crops, such as cereals, corn, roots, clovers, many of the grasses, strawberries, and raspberries, can be grown successfully on moderately acid to mildly alkaline soils. Alfalfa, sweet clover, mangels, cabbage, cauli-

[1] Although neutrality is precisely pH 7.0, for practical purposes soils with pH values of 6.8 to 7.2 may be considered neutral.

flowers, and asparagus thrive under slightly acid to moderately alkaline conditions. Potatoes grow well on strongly acid soils and the scab organism is inactive under these conditions. Some of the grasses, the bents and fescues, thrive best on strongly acid soils. A few plants, such as blueberries and cranberries, thrive only on strongly acid soils.

Effects on Soil

We add lime to the soil mainly to neutralize acidity, to precipitate metals such as aluminum and manganese that may be toxic to plants and to introduce calcium and/or magnesium. Furthermore, liming materials, by neutralizing the soil acids, give a better medium for microbiological activity. Thus soil organic matter decomposes better, releasing nitrogen and certain other plant nutrients in forms readily available to the roots of the growing crop.

Sources of Lime

Limestone is of two kinds: calcitic and dolomitic. The former consists mainly of calcium carbonate; the latter contains carbonates of both calcium and and magnesium. In dolomitic limestone, magnesium carbonate is generally present in somewhat lesser amounts than calcium carbonate. Both kinds contain varying amounts of inert rock material. The chemical composition of limestone determines its neutralizing power. The highest-quality limestones contain at least 95 per cent of calcium carbonate or of the carbonates of calcium and magnesium, and those of good quality contain at least 85 per cent.

Quicklime, known also as burnt lime or caustic lime, is produced by burning limestone (calcium carbonate) with wood or coal. The burning may be done either in a specially constructed kiln or by the simpler method of heap-burning. The intense heat decomposes the carbonate; carbon dioxide gas is driven off and quicklime remains. Quicklime is rarely used as a soil amendment since its lumpy condition does not permit uniform distribution.

Slaked lime, known also as hydrated lime, results from the union of water with quicklime. Slaking, or adding water to quicklime, generates a considerable amount of heat. The product is a whitish-gray or grayish-white powder (according to the quality of lime) that is distinctly caustic and alkaline. Lime swells to nearly double its original bulk when slaked, so that a bushel of freshly slaked lime weighs about 40 pounds, as compared with an average of 70 pounds for quicklime. Quicklime, however, ranges from 60 to 100 pounds per bushel, according to its degree of purity and the thoroughness of burning. As a rule, slaked lime is considerably more expensive to use than ground limestone or marl.

Air-slaked lime results from exposure of quicklime to the air. The lime absorbs moisture and is converted into the hydrate (slaked lime), which then combines with the carbon dioxide gas of the atmosphere to form the carbonate. Air-slaked lime, therefore, varies in composition; it may be mainly hydrated lime with a small percentage of carbonate, or largely calcium carbonate with only traces of the hydrated form, depending upon the length of the exposure and the depth of the heap.

Marl or shell marl is a naturally occurring deposit, consisting largely of calcium carbonate. Some marls are almost pure carbonate; others are more or less impure from the presence of clay, sand or organic matter, and these, of course, are of less value agriculturally. A marl containing, in the air-dried condition, from 80 to 90 per cent of calcium carbonate is of good quality.

Marls are usually soft and pasty in consistency, and frequently contain many small shells. When air-dried they become friable, and break down into a coarse powder that permits uniform distribution on the land. The air-dried material seldom requires machine crushing. Marl is therefore a very cheap and desirable source of lime as it may often be obtained for the cost of digging and hauling.

Indurated marl is a hard, rocklike material with a honeycombed structure, deposited by the waters of streams and springs rich in calcium carbonate. Large deposits, of a high degree of purity, occur in many British Columbia valleys. Crushing is usually necessary before this type of marl can be evenly distributed on the soil.

Shells and mussel and oyster muds are another source of lime. Along seacoasts, shells of various crabs, lobsters and other shellfish, as well as muds containing varying quantities of mussel, oyster and clam shells, can often be obtained at little or no cost. Since the shells themselves are composed almost entirely of calcium carbonate, they can be used to advantage on acid soils, though, unless crushed or ground, their action is rather slow.

Fineness of Ground Limestone

The finer the limestone is ground, the faster it is dissolved in the soil and the faster it corrects acidity and furnishes calcium for plant growth. Generally speaking, if prompt action is desired at least 50 per cent of the material should pass a sieve with 80 meshes to the inch. If immediate action is not required, a coarser limestone, 50 per cent of which passes a 40-mesh sieve, is satisfactory. In either case, all should pass a 10-mesh sieve.

Comparative Values of Lime Compounds

The forms of lime used in agriculture are not all of equal value for correcting acidity. In acid-correcting power, 56 pounds of quicklime are equivalent to 74 pounds of freshly slaked lime of equal purity or to 100 pounds of the carbonate, whether it be as marl or ground limestone. Air-slaked lime, for reasons already noted, may be partly hydrate and partly carbonate; its value is therefore intermediate between that of freshly slaked lime and the carbonate—that is, 56 pounds of quicklime equal between 74 and 100 pounds of air-slaked lime.

Further, 84 pounds of magnesium carbonate are equal in neutralizing power to 100 pounds of calcium carbonate. Hence 100 pounds of a dolomitic limestone containing 42 per cent of magnesium carbonate and 50 per cent of calcium carbonate are equal to 100 pounds of pure calcium carbonate. On the basis of the above relationships, the following are equal in neutralizing power: 2,000 pounds of calcium carbonate (limestone), 1,480 pounds of freshly slaked lime (hydrated lime), 1,120 pounds of quicklime and 1,840 pounds of dolomite (50 per cent calcium carbonate and 42 per cent magnesium carbonate).

If quicklime were worth $7 per ton, ground limestone equally free from impurities would be worth $3.92 per ton, and freshly slaked lime $5.30 per ton. Though the above comparisons of equivalent weights and values serve in a general way, an analysis is necessary to get the exact neutralizing value of a sample.

Application

Lime compounds may be applied in any season of the year, but fall or early spring is usually most convenient. If the material is applied to the plowed land in the fall the usual spring cultivation will incorporate the liming materials into the surface soil. Even distribution is important.

The rate of application of ground limestone and marl depends on the acidity and the texture of the soil and on the crop to be grown. It may vary from half a ton per acre on slightly acid soil to 2 tons on strongly acid soil. Where acidity is extreme, larger amounts may be used. Light sandy soils need less than heavier soils. Light applications of limestone at frequent intervals are preferable to heavy applications at long intervals.

If only quicklime is available it is better to slake it rather than grind it before distribution. Slaked lime is not difficult to apply but its dustiness and caustic nature make it unpleasant to handle. Quicklime and slaked lime, being caustic, are probably best applied in autumn or winter.

Benefits of Liming

Clover and alfalfa are the crops that benefit most by the application of lime, since they do not thrive on strongly acid soils and they use much lime. The application of lime also lessens the occurrence of clubroot in turnips and other plants subject to this disease, which is active only in acid soils. For potatoes, however, care is needed in the amount of lime applied. The organism that causes scab is inactive if the soil is sufficiently acid but may develop vigorously in moderately acid to alkaline soils.

SULPHUR

Sulphur is sometimes used as a soil amendment to increase acidity. When sulphur is applied to a soil under favorable conditions, it is converted into sulphuric acid within a few weeks through the action of microorganisms. One pound of sulphur gives about three pounds of sulphuric acid. Its effect on soil reaction is the reverse of that of ground limestone.

It has been estimated that, in order to reduce the soil pH from 7.5 to 6.5, about 400 to 600 pounds of sulphur would need to be added per acre to sandy soils, and about 800 to 1,000 pounds to clay soils.

Sulphur is effective in the treatment of black alkali soils; the sulphuric acid that is formed neutralizes the sodium carbonate that is present. Sulphur is somewhat less effective on calcareous soils that have considerable reserves of calcium carbonate.

Sulphur is also an essential plant nutrient. In most Canadian soils enough sulphur is present although there are many areas of Gray Wooded soils where it must be added to obtain satisfactory crop growth. Through the application of such fertilizers as ammonium sulphate, potassium sulphate and 20 per cent superphosphate, considerable amounts of sulphur are added to the soil and this tends to counteract any deficiency.

GYPSUM

Gypsum, commonly known in the ground form as land plaster, is a natural sulphate of lime (calcium). It is found in large deposits in various parts of Canada. Its chief value is probably on black alkali and saline soils. Although it supplies calcium for plant use, it is useless for the correction of soil acidity; consequently, its use in agriculture is not widespread. In addition to supplying calcium, gypsum is a source of sulphur. Where this element is deficient in the soil, gypsum applications have produced marked increases in yield, particularly on crops that need comparatively large amounts of sulphur, such as the legumes. Users of ordinary superphosphate (20 per cent) need not apply gypsum since this fertilizer contains calcium sulphate as a product of its manufacture.

CONVERSION FACTORS FOR METRIC SYSTEM

Imperial units	Approximate conversion factor	Results in:	
LINEAR			
inch	x 25	millimetre	(mm)
foot	x 30	centimetre	(cm)
yard	x 0.9	metre	(m)
mile	x 1.6	kilometre	(km)
AREA			
square inch	x 6.5	square centimetre	(cm^2)
square foot	x 0.09	square metre	(m^2)
acre	x 0.40	hectare	(ha)
VOLUME			
cubic inch	x 16	cubic centimetre	(cm^3)
cubic foot	x 28	cubic decimetre	(dm^3)
cubic yard	x 0.8	cubic metre	(m^3)
fluid ounce	x 28	millilitre	(ml)
pint	x 0.57	litre	(ℓ)
quart	x 1.1	litre	(ℓ)
gallon	x 4.5	litre	(ℓ)
WEIGHT			
ounce	x 28	gram	(g)
pound	x 0.45	kilogram	(kg)
short ton (2000 lb)	x 0.9	tonne	(t)
TEMPERATURE			
degrees Fahrenheit	(°F-32) x 0.56 or (°F-32) x 5/9	degrees Celsius	(°C)
PRESSURE			
pounds per square inch	x 6.9	kilopascal	(kPa)
POWER			
horsepower	x 746	watt	(W)
	x 0.75	kilowatt	(kW)
SPEED			
feet per second	x 0.30	metres per second	(m/s)
miles per hour	x 1.6	kilometres per hour	(km/h)
AGRICULTURE			
gallons per acre	x 11.23	litres per hectare	(ℓ/ha)
quarts per acre	x 2.8	litres per hectare	(ℓ/ha)
pints per acre	x 1.4	litres per hectare	(ℓ/ha)
fluid ounces per acre	x 70	millilitres per hectare	(ml/ha)
tons per acre	x 2.24	tonnes per hectare	(t/ha)
pounds per acre	x 1.12	kilograms per hectare	(kg/ha)
ounces per acre	x 70	grams per hectare	(g/ha)
plants per acre	x 2.47	plants per hectare	(plants/ha)